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Repairing brickwork

Brick buildings, like any others, can suffer damage through accident or long neglect and also as the result of deficiencies in design, materials or workmanship. This digest summarises methods of repair; its aim is not to over-emphasise the liability of brickwork to damage, but rather to point out certain risks that can be avoided and, more particularly, to indicate any special precautions that can be taken in the course of repair work to prevent recurrence of the trouble.

This digest is concerned with damage to small buildings, generally domestic, for which foundations are at shallow depth and settlement due to overloading the soil is unlikely. Whenever there is doubt about the stability of any part of a building, professional advice should be sought. The various causes of damage referred to briefly here are discussed individually and in greater detail in other digests: a list of these is on page 8.

Causes of damage

To ensure that repairs will be effective, it is necessary to know what caused the damage, but diagnosis is not always easy. Cracking of the brickwork, the commonest form of defect, can be due to one or more of a variety of causes, and until the causes have been identified there can be no certainty that a simple repair of the cracks is all that is needed. When a building has for some reason become damaged, the nature and timing of the repair work will depend very much on how far the stability of the walls has been endangered.

Ground movement

The slight initial settlement of a new building should not be sufficient to disturb brickwork, but differential settlements, leading to various degrees of cracking in walls, may occur during the life of a building for a variety of reasons. These include changes in soil strength due to changes in groundwater levels or site drainage, loss of support due to running sand, swallow holes, mining subsidence or local vibration effects and frost heave in chalk. Changes in the nature of the soil not detected by the site survey or inadequately consolidated made-up ground are also possible causes of differential settlement.

Thermal movement

Where a brick wall is restrained by structures at both ends without provision for movement, fluctuations in temperature may set up stresses sufficient to cause fracture or distortion of the brickwork. The diurnal and seasonal movements of a flat concrete roof can crack the supporting brickwork if proper precautions have not been taken. Other exposed concrete members at roof level, eg gutters, copings, ring beams, can cause similar problems, as can the thermal expansion of structural steelwork.

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Technical enquiries arising from this Digest should be directed to Building Research Advisory Service at the above address.

Drying shrinkage

Clay brickwork is rarely, if ever, subject to shrinkage cracking. Concrete or calcium silicate brickwork may become cracked, especially at window and door openings, as a result of drying shrinkage. The risk is minimised if the bricks are kept dry before and during laying, and are laid in mortar not stronger than 1 : 1 : 6 cement : lime : sand and, in the case of concrete bricks, are well matured. Movement joints should be provided at suitable intervals.

Shrinkage cracking is not progressive and is not likely to impair strength or stability. The chief objection, apart from the appearance, is that the cracks might make it easier for rain to penetrate.

Fire

The effects of fire vary according to the severity of the fire, the thickness of the walls and the type of brick. In a severe fire, cracking and bulging of the brickwork is to be expected, in addition to surface damage, eg spalling or, perhaps, if the fire is very intense, some vitrification of clay bricks. Clay bricks, having been exposed to fire in manufacture, are less likely to suffer damage than concrete and sand–lime bricks. The sudden quenching of brickwork with water in the course of fire-fighting may cause spalling but generally it does not affect the strength and stability of the wall seriously. More important is the distortion caused by thermal movement of members built into the wall. The high temperature reached in a fire will cause gross expansion of structural steel members (beams, roof trusses, even lintels) built into, or resting on, brickwork. This is likely to displace the brickwork and cause cracking.

Roof spread

Pitched roofs that have been inadequately tied will, under the action of dead loads and wind loads, spread appreciably at the eaves, and instances of walls being pushed out by as much as 50 mm at the top have been reported. The roof structure must be suitably strengthened before the walls are repaired.

Sulphate attack

Cement-based mortars may be attacked by sulphates derived from clay bricks themselves, or, sometimes, from external sources such as sulphate-bearing soils, flue gases or from gypsum plaster wrongly used in a mixture with Portland cement in the mortar. The attack is gradual and occurs only when the brickwork remains wet for long periods. The resulting slow expansion of the mortar produces various forms of cracking and deformation of the brickwork, and sometimes spalling of the edges of individual bricks; the mortar may also deteriorate. In severe instances, the stability of the brickwork may be impaired. Sulphate attack is also a frequent cause of failure of renderings on clay brickwork.

A common example of this defect used to be seen in the damage to unlined brick flues serving slow-combustion domestic boilers. Building Regulations now require flues serving controlled combustion appliances to be lined; when a new heating appliance is connected to an old flue, the flue must be lined.

Sulphate attack can often be recognised from the signs mentioned; chemical tests can be used for confirmation or diagnosis.

Expansion on wetting

Some clay bricks undergo a slight expansion after leaving the kiln which often causes vertical cracking of the brickwork; these cracks occur at or near the quoins of short returns or setbacks in the elevations of brick structures. This expansion is also one of the causes of movement of brickwork at ground level; expansion and slip along the

dpc results in oversailing at the corners. If sliding is resisted, bowing of the brickwork may occur instead at that level. Most of the expansion and movement due to this cause takes place quite early in the life of the building and damage is not, therefore, likely to be progressive or to recur. This expansion can also cause difficulties where external brick panels are built into a reinforced concrete frame. The forces developed due to the expansion of the brickwork acting against the shrinkage in the concrete frame can be sufficient to displace brick slips used to cover floor edges and produce bowing and damage in the panels.

Another cause of outward movement of brickwork and cracking at ground dpc level is the swelling of materials used as hardcore or filling under the concrete floor. Some shales and clays may swell when wetted. Additionally, some fill materials may cause attack on concrete and brickwork mortar.

Corrosion of embedded iron and steel

The corrosion of iron and steel embedded or enclosed in brickwork may cause opening of the brickwork joints or cracking of the brickwork and rust staining. Thus, where a steel beam is in contact with a brick cladding, rusting of the steel may displace the courses of bricks immediately covering the beam by 25 mm or more, beyond the main face of the brickwork. Rusting of a stanchion similarly covered may produce a wide vertical crack and disrupt the brickwork. The rusting of unprotected cramps or reinforcement embedded in the brickwork can also cause trouble. Ferrous metals so embedded should always be protected from rusting by one or other of the recognised methods, eg by coating with bitumen, anti-corrosion paint or metallic zinc plus paint.

The corrosion of wall ties in cavity brickwork produces cracking along mortar beds every fourth course. Walls constructed using black ash mortar are particularly prone to this type of failure but it can occur with ordinary Portland cement mortars, particularly if sub-standard ties have been used, and in walls which are severely exposed.

Unsound materials

Occasionally, brickwork suffers damage because of unsoundness of the mortar, or of the bricks themselves. The presence of imperfectly slaked lime in a mortar can produce effects ranging from minor pitting of the mortar to general expansion with deformation and cracking of the brickwork. Unsound clinker or ash in a mortar may give similar troubles.

Unslaked nodules of lime in individual clay bricks may cause 'blowing' or spalling of the bricks when they are first wetted. Usually this effect occurs quite early, often before the bricks are built into the wall. In rare instances, lime more evenly distributed in small particles throughout several bricks in a batch causes large expansions in the bricks affected and severe cracking of the brickwork, even before building is completed.

Frost

Frost will damage brickwork only when it is very wet. In Great Britain frost failures are usually confined to partly-built unprotected brickwork or to brickwork subject to conditions of severe exposure, ie free-standing walls, parapets and retaining walls, and occasionally brickwork below ground dpc. Bricks intended for such use should be selected for good frost-resistance.

The characteristic effects of frost are spalling of the face of individual bricks (or, in the worst cases, more general disruption) and disintegration of the mortar. In some instances, frost may only have accelerated damage due primarily to some other cause, such as sulphate attack.

Salts

The commonest effect of soluble salts in the brickwork is to produce an efflorescence which, although unsightly, is usually temporary and harmless to the bricks. Occasionally, crystallisation of salts within the brick may cause some spalling or disintegration of the surface, similar to the effect of frost. The salts may be derived from the bricks or the mortar, from soil in contact with the brickwork, from the run-off from materials such as limestone in polluted atmosphere, or from sea spray. Sea salts tend to keep the brickwork permanently damp. The chief potential danger to brickwork from the presence of salts is that of sulphate attack on the mortar and applied renderings, as already described.

Repairing the damage

It may be established that strength and stability are not affected and that repairs can safely be delayed until all movement has ceased and the weather is favourable. Notwithstanding this delay, if it is intended to claim damages under the terms of an insurance policy, the insurance company should be notified when the damage is first observed.

Strength and stability of damaged walls

Where the safety of a building is in question, the local authority has a statutory responsibility to see that the structure is made safe. Apart from this, professional advice should generally be sought before undertaking any major repair work, or in case of doubt. The following notes, therefore, are intended for general guidance only.

It is not always easy to judge from appearance how far damage to brickwork is likely to affect the strength or stability of the structure. No firm rule can be applied but in general it can be taken that simple cracking, even with quite wide cracks, may not be too serious provided the brickwork is not also distorted or much out of plumb.

If a wall is out of plumb not more than 25 mm or bulges not more than 10 mm in a normal storey height, no repair would usually be needed on structural grounds alone.

A check should be made of the bearing area of joists, lintels and roof timbers to ensure that there has not been a significant loss of support; any flat arches of brickwork over openings should not show wide cracking at the abutments. In the case of solid walls it should not be assumed that faces are properly bonded across the thickness. Such a wall which shows a bulge on one face which is not visible on the other should be treated with caution.

With cavity walls, the effects of leaning or bulging, and of eccentricity of loading, will usually be more serious than with solid walls. The stability of the wall as a whole, and particularly unloaded external leaves, will depend very much on the effectiveness of the wall ties, which in turn depends on the anchorage in the mortar joint and the extent to which they may have been corroded. Where the mortar is weak, the stability of a cavity wall even slightly out of plumb (say 25 mm in a storey height) would be suspect; but the inner leaf, if steadied by cross-walls, roof members and floor joists, might still be considered stable. Rebuilding the whole outer leaf (with special wall ties if necessary) would then be the most appropriate measure. It is the inner leaf which carries most of the superimposed load; if only the outer leaf is distorted, the effect on stability is less serious than if both are affected.

The significance of any defect in a wall must be judged in relation to the building as a whole and the general soundness of its construction, and also to the particular function the wall is called upon to serve and

its suitability for its intended purpose. Function and suitability are not always immediately obvious. For example, internal division walls without adequate foundations sometimes carry the major part of the roof and upper floors, while outside walls of more substantial construction may carry much lighter loads: walls are often cut up by windows and bays into disconnected narrow piers; arches over doorways often have such slight abutments that they are incapable of acting as arches.

As a general guide, when considering the treatment required for walls that are apparently sound, except for a moderate tilt or bulge, the additional factors that need to be taken into account are the following:

(1) The nature and condition of the wall and of the footings on which it is carried.
(2) The position and bonding of cross-walls and chimney breasts, and of beams, anchors and roof timbers which provide the wall with lateral restraint.
(3) Whether floors, roofs, upper walls, etc., are liable to exert thrust, or are so tied as to restrain tendency to further movement.
(4) The existence and severity of vibration caused by probable users of the building and by nearby road and rail traffic.
(5) The influence on users, or prospective purchasers, of a building which appears to them unstable, even if it is in fact stable.

Treatment of structural damage

For brickwork severely damaged by non-continuing causes, eg fire or explosion, or for old walls becoming unsafe through neglect, the following are examples of treatments which have been adopted:

(a) To provide tie-rods, passing through the house in the thickness of a floor, or at roof level, anchoring the suspect wall to another wall or structural member that is sound, or tending to move in the opposite direction.
(b) To build a buttress, or buttresses, keyed into the suspect wall, carried to a stable base, and firmly secured by such methods as are used in underpinning, to ensure that the buttress actually thrusts against the wall in the direction intended. A buttress built against a wall and itself liable to settlement may only be an additional cause of movement in the direction in which it is intended to provide restraint.
(c) To pull down the part of the wall that is bulged or out of plumb and replace by new brickwork.

Of the methods suggested above, the use of tie-rods is generally the cheapest and the most effective; but owners and purchasers may be prejudiced against a building that has been tied together, however effectively. The method is traditional and is common in mining districts where buildings so tied are allowed to stand for many years with degrees of tilt that would be considered unsafe elsewhere.

When walls are partially rebuilt, a Portland cement: lime: sand mortar (1 : 1 : 6 by volume) is most generally suitable, whatever the mortar used in the original wall. Stronger mortars are more likely to lead to cracking between old and new work, and weaker mortars may give insufficient resistance to initial or long-term movements and may weather more on the face.

The proper structural connection of new to existing work should be ensured by toothing at vertical or raking junctions and by hard packing along the full length of horizontal joints; a dry mortar mix, well rammed in, is often the most effective way of ensuring full load transfer without excessive deflection after the removal of temporary supports.

Cement: lime: sand mixes have been given for mortars but equivalent mixes using a plasticiser or masonry cement would also be appropriate.

Other repairs

Where the total damage is not sufficient to impair structural stability, cracks, surface defects and minor displacements of the brickwork can be treated individually. Where movement has not stopped, it is not advisable to make a permanent repair. For example, when there has been foundation movement in shrinkable clay soils and the ground is still in a drying phase, the cracks will be likely to continue to widen; if the clay is wetting up after a dry spell, it will be expanding and the cracks tending to close. The cracks may be left but if there is a risk of rain penetration, a mastic applied by caulking or by gun may be used as a temporary measure; this will also prevent debris 'locking' the crack.

Cracks

There is a general distinction, in appearance, between cracks that run more or less diagonally, following vertical and horizontal mortar joints alternately, and those that pass straight down through alternate vertical joints and the intervening bricks and mortar beds. In repair work, this distinction is significant only when it is considered necessary to cut out and replace the cracked bricks. The decision whether or not to repair cracks and cut out bricks will depend mainly on two considerations: whether the cracks are unsightly and whether, if not repaired, they are likely to encourage rain penetration.

Fine cracks (up to about 1.5 mm wide) are not very conspicuous and, in faced brickwork, pointing would often make them more unsightly; moreover, if the bricks are absorbent, rain entering the cracks is not likely to pass through the wall. Fine cracks, therefore, can often be ignored but repairs may be advisable in the particular case of non-absorbent bricks in a wall exposed to prevailing wet winds. The procedure then would be to cut out all cracked bricks and rake out joints along which the crack has passed; rebond with stretchers where bricks have been cut out, using a 1 : 1 : 6 cement : lime : sand mortar, fill the cracked joints with the same mix and repoint.

Wider cracks will generally need to be repaired, and the procedure will vary somewhat according to the nature of the mortar in the existing work. Where the mortar is not too hard, rake the joints squarely to a minimum depth of 15 mm on both sides of the walls if accessible; fill and point with mortar not richer than a 1 : 2 : 9 mix of cement : lime : sand; where the existing mortar is very weak, use a 1 : 3 : 12 mix. With stronger mortar joints, either cut out the bricks adjacent to the crack and rebond, using a 1 : 1 : 6 cement : lime : sand mortar, or point the joints. With cracks passing through bricks and mortar, cut out and rebond, using mortar similar to that in the existing wall.

When repairing cracks with mortar as suggested above, it is important to obtain good adhesion between the mortar, the existing work and the new bricks. A strong mortar should be avoided and the use of a well-graded sand will help to keep shrinkage to a minimum. To promote good adhesion the brickwork, if porous, should be wetted before the mortar is applied. Wetting of clean surfaces is not essential if a water-retaining additive (eg a cellulose ether) is used in the mortar. Alternatively, a proprietary external grade filler may be used.

Surface damage

Where the jointing mortar has become damaged without disturbing the brickwork, perhaps under the action of frost or fire, the joints should be raked out to a depth of at least 15 mm and repointed. A common mistake is to use too strong a pointing mortar. With soft brick, the mortar should not be stronger than 1 : 2 : 9 cement : lime : sand. Since such a mortar is vulnerable to frost until it has dried and hardened, the work should preferably be done in spring or summer; alternatively, the wall should be protected by coverings until the

mortar has hardened. For bricks of medium or high strength, the mortar for pointing should not be stronger than the bedding mortar and normally a 1 : 1 : 6 mix would be suitable.

Spalling of the bricks usually affects only a small proportion of those in the wall. If the remainder appear sound, the damaged bricks can be cut out to the required depth and the work refaced either with whole bricks or with slip tiles about 50 mm thick. If matching bricks are not obtainable, it may be possible, in the case of a cavity wall, to extract the damaged bricks and turn them, rebuilding into the wall to present the undamaged face.

Matching such repairs with the rest of the wall is difficult and it may often be better to leave things as they are until complete refacing becomes necessary; this could be done by means of a new leaf bonded to the old at intervals by non-ferrous or stainless steel cramps or ties. Instead of refacing partly or wholly with brick, the wall could be rendered, provided the bricks are hard and sound enough to hold a rendering. If not, slate-hanging or tile-hanging or timber cladding may be considered as possible treatments; the alternative of rendering on expanded metal fixed to the wall is less desirable because of the risk of ultimate cracking of the rendering and corrosion of the metal lathing.

Minor displacement of the brickwork

Horizontal displacement of parts of the brickwork is not very important unless the movement is large enough to endanger the structural stability. It is usually sufficient to rake out the joints on which movement has taken place and repoint. The need to do this is greatest where a course of bricks projects so as to form a ledge where water may collect.

It is always advisable, however, to find out what has caused the movement and take any steps necessary to prevent its continuing; this may sometimes mean removing the bricks displaced, for example where the trouble is due to the corrosion of embedded metal.

Special treatments

Sulphate attack

The effects of sulphate attack show themselves as expansion of the jointing mortar or, on rendered walls, predominantly horizontal cracking of the rendering. Later, the rendering becomes hollow and more badly cracked and portions may fall away. The brickwork may distort and crack progressively, and in some instances, eg in chimney stacks, become unsafe. Repair will thus depend upon how far the action has gone, but in any case the action will be liable to continue unless the brickwork can be dried out and kept reasonably dry.

As a general guide, it can be said that where rebuilding is necessary, as in chimney stacks and badly damaged walls, the bricks used should be of low sulphate content and the mortar a 1 : 1 : 6 mix of sulphate-resisting Portland cement : hydrated lime : sand. The main precaution in all cases, however, should be to obviate further attack by excluding the conditions of dampness that gave rise to the trouble. Attention should therefore be paid to any positions, such as parapets, where water may have entered because of faulty detailing or absence of damp-proof courses.

On rendered work, especially when too strong a mix has been used, shrinkage cracks often provide the means of entry of water and thus encourage sulphate attack on the rendering and the mortar joints. Rendering that has become damaged in this way should not be patched, but stripped off and the brickwork allowed to dry. If re-rendering is then necessary, a weaker mix of sulphate-resisting cement, lime and sand should be used, but preferably the brickwork should be left bare (where appearance is unimportant) or covered by cladding.

Corrosion of wall ties

Wall ties which are corroding because the galvanising or other protection has failed will continue to rust and therefore expand until no metal remains. It will therefore usually be advisable to remove any metal which remains in the outer leaf. Repair methods which have been used are as follows:

(a) Completely rebuild outer leaf.
(b) Drill wall and fix new corrosion-resistant ties (eg stainless steel) using expansion fixing or epoxy adhesive. Ideally, old ties should be cut out.
(c) Fill cavity with polyurethane foam. The long-term effectiveness of foams as substitutes for ties has not been established but at least one product has an Agrément certificate. There is a likelihood that corrosion of the old ties will continue and cause further cracking.

Corrosion of embedded iron and steel

It will usually be necessary to open up the brickwork to gain access to the steelwork. If it is found that corrosion is not too far advanced, the metal may be thoroughly cleaned, primed with a rust-inhibiting paint and coated with bitumen before restoring the brickwork. If corrosion is well advanced, it will probably be necessary to replace the steelwork either with carefully protected steel or with stainless steel, non-ferrous metal or reinforced concrete.

In rebuilding, whatever steps are practicable must be taken to reduce moisture penetration through the brickwork.

If only the ends of metal members are embedded particular attention should be paid to the protection of the metal where it enters the brickwork; the socket should be caulked with bituminous compound at the point of entry.

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